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HABITAT SUITABILITY INDEX AND CAPABILITY MODELS FOR THE GREAT GRAY OWL IN CALIFORNIA

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CONTENTS

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GREAT GRAY OWL (Strix nebulosa)

HABITAT USE INFORMATION

A. General

The distribution of the great gray owl (Strix nebulosa) is circumpolar and it is considered rare throughout its range (Hoglund 1969). It breeds in the forests of Northern Eurasia from Scandinavia eastwards and in the Neartic regions of North America (Blair 1962). Most North American records are from Manitoba (Nero 1969, 1970a, 1977). South of Canada it is a permanent resident only in the Northern Rockies and the Pacific Coast states south to the central Sierra Nevada (various authors).

Required habitat for great gray owl breeding in the Sierra Nevada is coniferous forest in association with meadows (Winter 1980, 1981, 1982). It experiences periodic breeding fluctuations associated with population cycles of montane vole (Microtus montanus), the favorite prey (Winter 1982, 1984). The great gray owl is considered rare in California (Grinnell and Miller 1944, Winter 1984) and may have suffered population declines in recent years due to habitat modification (Winter 1980).

The current population estimate for California is 60 to 70 birds and the center of breeding activity is located in Tuolumne, Mariposa, Fresno and Madera counties (Winter 1984). Based on historic sightings, potential habitat exists throughout the Sierra Nevada and Northern California mountains but there are few recent reports outside the Yosemite Region.

B. Food Requirements

The great gray owl is highly dependent on the vole subfamily (Microtinae) as prey. In Sweden, a 6-year study showed that voles comprised 89.5% of the diet (Hoglund 1969). In Finland another study found 97.6% of the diet to be Microtus spp. and Clethrionomys spp. (Pulliainen 1977). Additional prey taken by Old World great gray owls include shrews (Soricidae) and other small mammals (Hoglund 1969; Mikkola 1970; Pulliainen 1977). Nero (1969) found the diet in Manitoba to be 61% meadow vole (Microtus pennsylvanicus), 7% heather vole (Phenacomys intermedius), 30% masked shrew (Sorex cinereus), and 2% Norway rat (Rattus norvegicus). In Quebec, the primary prey species was the meadow vole (Brunton 1971).

In western North America the great gray owl has adapted to include the pocket gopher as a diet mainstay. Craighead and Craighead (1956) found the prey base in Wyoming to consist of 66.3% meadow vole, 27.7% pocket gopher (Thomomys bottae), 3.6% red squirrel (Tamiasciurus hudsonicus), 1.2% white-footed mice (Peromyscus spp.), and 1.2% small birds. In the Sierra Nevada, Winter (1982) found the pocket gopher to be the predominant prey item but montane vole was also highly important. The long-tailed vole (Microtus longicaudus) is another important prey species (Winter 1985). It is less cyclic than montane vole (Jenkins 1948) and may, therefore, be more important in poor vole years. Great gray owl occurrence in the Sierra Nevada is entirely within the population range of the montane and long-tailed voles (Anderson 1959; Ingles 1965; Verner and Boss 1980).

Great gray owls hunt by perching 0.7 to 6.1 m high (Winter 1981) at the edges of meadows or grasslands and listening for prey in grass runways or underground burrows and then flying low over the ground and dropping on the prey (Brunton 1971, Nero 1969, Winter 1981). When taking a gopher, the bird breaks through the burrow above the animal (Tryon 1943, Winter 1981). The longest prey stoop seen by Winter (1982) was 61 m and the average was 9.1 m.

Based on a study by Pulliainen and Loisa (1977), Winter (1982) estimates the daily food requirements to be 100 gm for a male and 140 gm for a female, or 11-12% of the body weight. Craighead and Craighead (1956) reported an average daily consumption of 77 gm for a captive female great gray owl. Winter (1982) estimated average prey weights in the Yosemite region to be 104 gm for pocket gopher and 39 gm for montane vole. During the breeding period only the male hunts, normally just at night, but also during the day when food requirements at the nest increase or when prey availability is low (Pulliainen 1977, Winter 1982).

Great gray owls in Eastern Oregon forage in a variety of forest and grassland habitats (Bull 1985). These include mixed conifer and pine stands which have herbaceous vegetation in the understory. In the Sierra Nevada, meadows appear to be the most important hunting habitat for great gray owls since about 93% of their prey are taken there (Winter 1981). Nearly all great gray owl observations in California are in or near meadows, mostly in the Yosemite region of the Sierra Nevada (Winter 1980). The meadows, generally 10.1 ha (25 ac) or larger (Winter), are characterized by receiving little or no livestock grazing, and being in good ecological condition (i.e. dominated by a variety of climax perennial grasses, sedges and forbs) (pers. obs.). Brunton (1971) observed that the owl did not occupy heavily grazed areas in Quebec and Winter (1985) feels that heavy grazing causes meadows to be unsuitable for great gray owl because of its detrimental effects on vole populations.

C. Water Requirements

The literature does not mention dietary water requirements. Most water is probably provided by the metabolic process of digesting food. Winter (1981) noted that all meadows supporting great gray owls in the Yosemite region had permanent water flowing through them. Anderson (1959) notes that montane vole, a principal food item, always occurs near water.

D. Cover Requirements

In Manitoba, Nero (1969) reported that great gray owls hunted in open fields and meadows but that they were seldom far from heavy spruce forests provided by two major forest reserves. In the Yosemite region, the owls require forests suitable for providing nest snags, daytime roosting habitat, and hunting perches near meadow edges (Winter 1980, 1981, 1982). Within Yosemite National Park, where most known breeding in the region occurs, the forests are typically old-growth mixed-conifer or red fir-lodgepole pine at elevations between 1400 and 2440 m (4600 and 8000 ft). At Ackerson Meadow, in the Stanislaus National Forest, breeding

occurs regularly where the forest cover is mostly second-growth with stands 15.3 to 45.7 m tall and between 40% and 100% canopy closure. In his study at Ackerson Meadow, Winter (1982) found that great gray owls day-roosted an average of 89.8 m from the nearest meadow at a mean height of 11 m and that 87% of these roost sites were in the shade. No preference for tree species was apparent but the great gray owls did prefer trees with a dbh greater than 22.9 cm (9 in) for day-roosting as well as for hunting perches (Winter 1982). For hunting, the owls at Ackerson Meadow used a mean perch height of 3.3 m in trees with an average dbh of 33.3 cm (13.1 in)(Winter 1982).

E. Reproduction Requirements

Great gray owls usually nest in abandoned hawk nests over most of their range (Bent 1938; Hoglund 1969; Mikkola 1972, in Burton 1973). Of 39 nests located in Oregon, 44% were stick, 19% mistletoe clumps, 21% snags and 18% artificial platforms (Bull 1985). In California all nests reported have been in the tops of broken snags (Winter 1980). Six nests in snags in the Yosemite region were all within 183 m (600 ft) of a meadow, ranged from 61 to 168 cm (24 to 66 in) dbh and were 7.6 to 22 m high (mean = 12.5 m)(Winter 1980, 1985). Seven great gray owl nests in Finland were located an average of 80.5 m from a clearing or bog-edge (Pulliainen 1977, in Winter 1982). In 1985 an artificial nest tree, cut to simulate a broken snag, was used successfully by a pair of great gray owls at Ackerson Meadow. It measured 91.4 cm (36 in) dbh and 12.2 m high. It is not unusual for nests to be used repeatedly (Parmalee 1968; Winter 1980; Bull 1985).

Winter (1980) reported that hawk nests near meadows are rare in the Sierra Nevada and that because of the large size of old growth trees great gray owls have adapted to use broken-topped snags for nesting. Two areas in Yosemite National Park with numerous breeding records were sampled for snag abundance by Winter (1980). He found 12.8 and 13.7 snags per ha (5.18 and 5.55 per ac) which measured 61 cm (24 in) or more dbh at the two meadows.

Shading of nest trees is important (Winter 1984 pers. comm.). In 1985 the female adult and young on the Ackerson Meadow nest suffered heat stress and heat probably accounted for the loss of one of the nestlings (Smith 1985). Hogland (1968) reported that in Sweden the departure of young from the nest at 20-29 days of age was caused by heat from the sun.

In the Ackerson Meadow study nests were not found but the center of three adjacent territories were an average of 1.3 km (.8 mi) apart (Winter 1982). In Sweden two pairs of great gray owl nested 100 m apart and in another case two nests were 400 m apart (Hoglund 1968).

Blair (1962) reported that the great gray owl does not breed regularly in any part of its wide range and that their breeding cycle coincides with peak populations of the various vole species. Breeding in the Yosemite region is also irregular (Winter 1981). Winter (1982, 1984) concludes that it reflects year-to-year abundance of montane voles which are one of the preferred prey items. Jenkins (1948) suggests that montane voles routinely cycle from less than 25 animals per ha to over 250, and sometimes over 2500 per ha while long-tailed voles have more stable populations.

F. Interspersion Requirements

Great gray owls require grassland and forest habitat in close proximity (Nero 1969; Winter 1980, 1982). In Quebec the home range for a wintering great gray owl was 45 ha (112 ac)(Brunton 1971). In Manitoba breeding great gray owls were seldom seen more than 0.8 km from the nest tree (Nero 1970b, in Kondla 1973), which indicates a maximum territory size of 202 ha (500 ac). At Ackerson Meadow, Winter (1982) measured home ranges for three pairs of breeding great gray owls to be 386, 232 and 155 ha (956, 574 and 383 ac). The ratio of meadow to forest in that study ranged from 13:87 (386 ha) to 24:76 (155 ha). Great gray owls at Ackerson Meadow were within 183 m of a meadow in 90% of the 566 observations taken (Winter 1982).

Winter (1982) estimated 10.1 ha (25 ac) as the minimum meadow size for a highly suitable nest territory in the Sierra Nevada on the basis of repeated breeding at 12.1 ha (30 ac) Crane Meadow in Yosemite National Park. Wilson Meadow, consisting of several small meadows totaling 5.7 ha (14 ac), is the smallest on record to support successful breeding (Smith 1981, Winter 1984).

Optimum habitat is created by narrow or undulating meadows with maximum forest edge relative to the meadow (Winter 1982). Large meadows may be unsuitable for hunting over 61 m (200 ft) from the forest edge unless there are trees or small stands interspersed in the meadow to serve as hunting perches (Winter 1982). At Ackerson Meadow a great gray owl utilized wood fence posts as perches to hunt portions of a large meadow (Winter 1982).

G. Special Considerations

The great gray owl is characteristically tame and conspicuous (Nero 1969). This attribute makes it susceptable to shooting and it has been exterminated in some areas as settlement occurred (Baines 1954, in Nero 1969). It was listed as an Endangered Species by the California Department of Fish and Game in 1980 and is designated a Sensitive Species by the USDA Forest Service in California.

An important factor limiting distribution is climate. Because the species is adapted for cold northern regions nest mortality can occur at latitudes or forest elevations where temperatures exceed the owl's heat tolerance. (Winter 1985 pers. comm.).

HABITAT SUITABILITY INDEX (HSI) MODEL

A. Model Applicability

(1) Geographic area. This model has been developed for application in the Sierra Nevada at elevations above 1220 m (4000 ft).

(2) Season. This model was developed to evaluate habitat needs of the great gray owl during its breeding season (April through September).

(3) Cover types. The two cover types required by the great gray owl in this geographic area, evergreen forest and grassland, are included in this model.

(4) Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required for a species to successfully live and reproduce. Based on estimated meadow requirements and reported forest use patterns it is assumed that at least 121 ha (300 ac) of suitable habitat (at least 10% as meadow) must be available for the great gray owl to occupy an area. If less than this total is available, or if less than 12 acres of suitable meadow is present, the HSI is assumed to be 0.0.

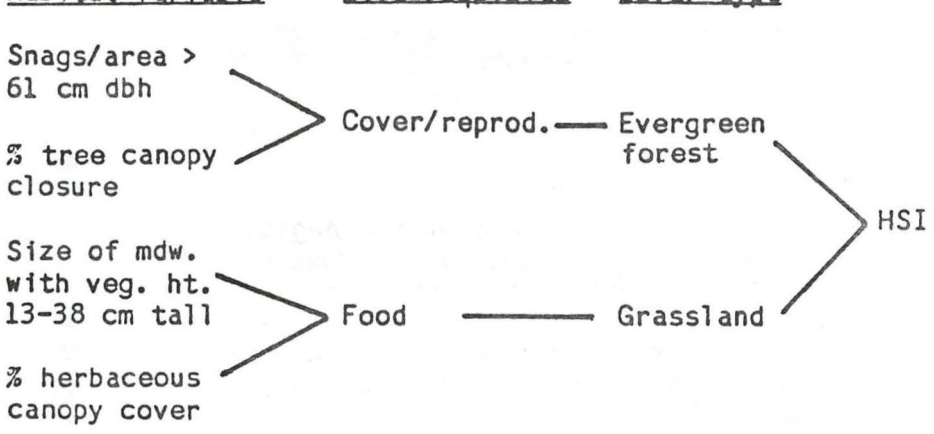
(5) Verification level. This HSI model provides habitat information useful for impact assessment and habitat management. The model is a hypothesis of species-habitat relationships and does not reflect proven cause and effect relationships. Earlier drafts of this model have been reviewed by Mr. Steve Laymon, University of California at Berkeley, Dr. Jared Verner, USDA Forest Service, PSW Forest and Range Experiment Station, and Mr. Jon Winter. Improvements and modifications suggested by these persons have been incorporated into this model.

B. Model Description

(1) Overview. This model considers the quality of the cover, reproduction (nesting) and feeding habitat needs of the great gray owl and determines overall habitat suitability. It assumes that water is not limiting.

The relationship between habitat variables, life requisites, cover types and the HSI for the great gray owl is shown in Figure 1.

Figure 1: Relationship between habitat variables, life requisites, cover types, and the HSI for the great gray owl.



(2) Life requisite components

(a) Food. Assumptions: Food suitability for the great gray owl is related to the abundance of two species of vole. This relationship is based on the indications that voles are the optimum prey item and that reproductive success of great gray owl is correlated with their population cycles. Of principal importance is the montane vole.

Generally the abundance of voles is related to the structure of the herbaceous vegetation and this structure can be adequately estimated by measuring the height and density. This will not, however, account for the natural population cycles of the vole.

Optimum vegetation height is assumed to be 13 to 38 cm (5-15 in) tall. If a large proportion of the meadow is in this height class, combined with adequate density, conditions will be optimum. Very short vegetation may be caused by livestock grazing or natural site factors and will not provide adequate cover for montane voles. Taller vegetation may limit suitability for voles as well as making prey capture more dificult for the owl. This includes such plants as willow (Salix spp.) and corn-lily (Veratrum californicum) if they are abundant in the meadow.

Optimum meadow vegetation cover is between 50% and 100%. Less than this amount limits food selection as well as hiding cover needs for the prey species.

Meadow systems comprised of perennial grasses, sedges and forbs must be at least 5 ha (12 ac) to provide an adequate prey base for great gray owls during high vole population cycles, and at least 10.1 ha (25 ac) is needed to provide an adequate prey base during average or better vole years.

(b) Reproduction. Assumptions: Reproductive value is related to the availability of suitable nest snags in proximity to the meadow prey base, assuming that old hawk nests are generally not available in these areas. The availability of suitable nest snags can be adequately estimated by measuring the density of large snags within 183 m (600 ft) of suitable habitat. A minimum of four conifer snags, 61 cm (24 in) or greater dbh, per acre are needed to provide optimum suitability, and if no snags are available in this size class, reproductive suitability will be absent.

Human disturbance may have a negative impact on nesting great gray owls. Even though the species is remarkably tolerant of nest observation other types of human activity such as construction or ORV use may be detrimental. The field user should assume that noisy, intrusive activities within 1/4 mile of an active nest or nesting area will reduce the reproduction value, possibly to zero.

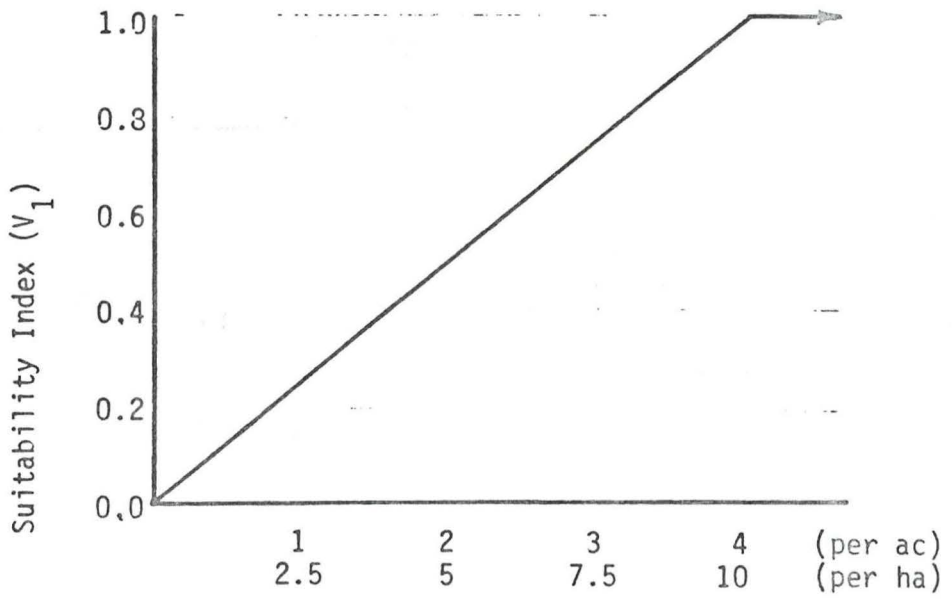
(c) Cover. Assumptions: Cover is primarily required for nest concealment and shading, daytime roosting, and hunting perches. Large trees giving 30% to 70% canopy closure provides useable habitat and canopy closure over 70% provides optimum conditions. It is assumed that forest stands with a canopy closure less than 30% have an HSI of 0.0.

(3) Interspersion of life requisites. Assumptions: The best habitat for the great gray owl contains high quality food habitat over 10% to 30% of the area and suitable cover/reproduction habitat on the other 70% to 90%. Several small meadows spaced up to 0.4 km (1/4 mi) apart over a 1.6 km (1 mi) distance may comprise the required feeding habitat. Normally it is expected that nesting territories will be 121 to 405 ha (300 to 1000 ac) in size. The life requisite assumptions are based on information from the literature, from the 1980-81 study at Ackerson Meadow and from the author's knowledge of the physical characteristics of suitable habitat in the Yosemite region.

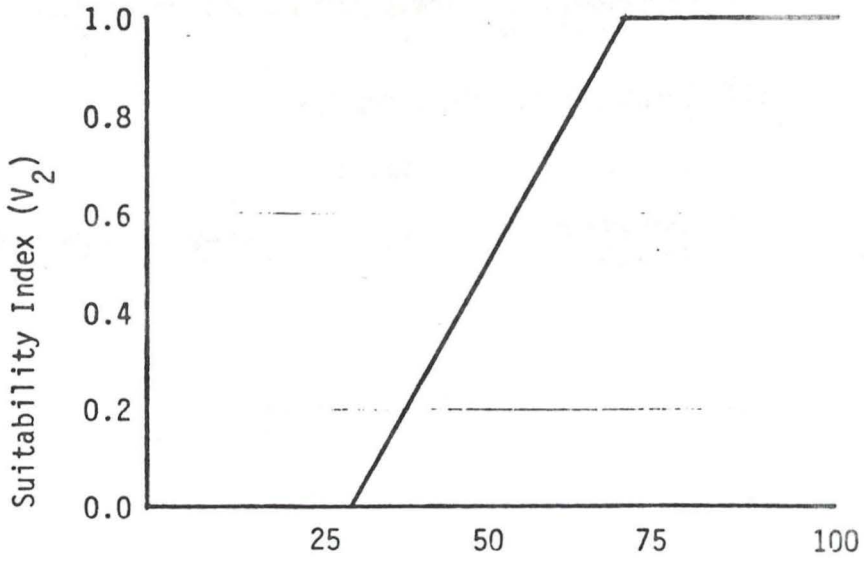
C. Model Relationships. This section contains suitability index curves and equations to quantitatively describe the relationships discussed in the previous section. These curves and equations can be used to produce an HSI for the great gray owl.

(1) Suitability index curves

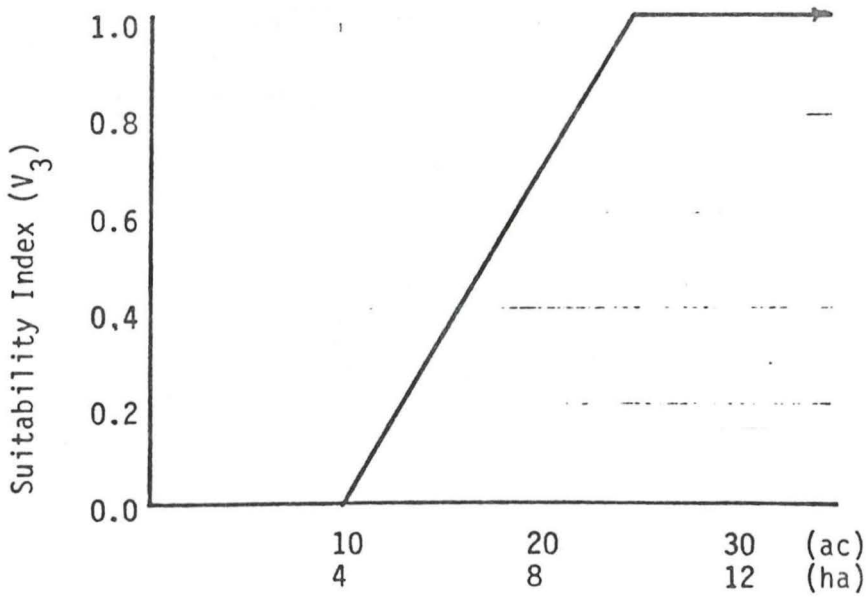
cover type	variable	
evergreen forest	V_1	snags per ha and ac > 61 cm (24 in) dbh



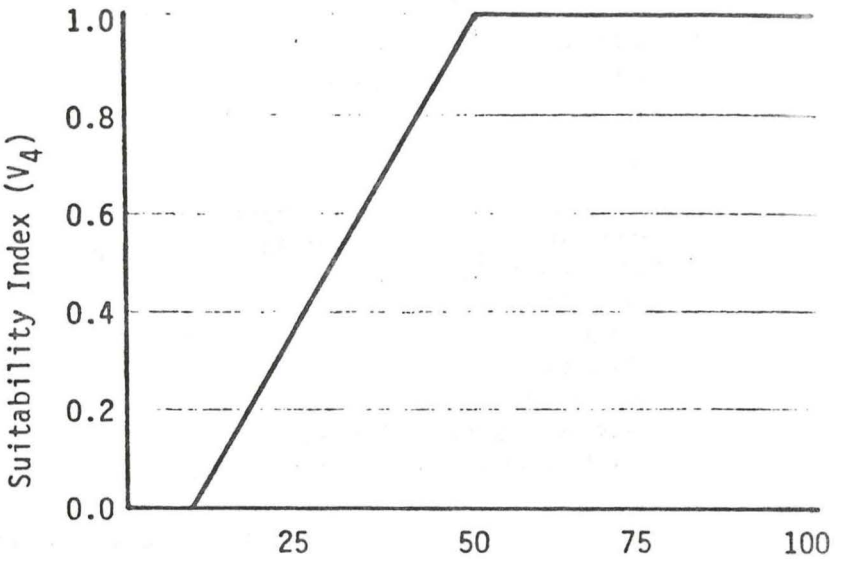
evergreen V_2 percent tree canopy closure of trees over 15.2 m (50 ft) tall



grassland V_3 size of meadow with herbaceous cover 13 to 38 cm (5 to 15 in) tall



grassland V_4 percent herbaceous canopy cover



(2) Equations

(a) Equation for food component. The following equation integrates index values for each variable to obtain a life-requisite value for food.

cover type	equation
G	Food Value = $(V_3 \times V_4)^{\frac{1}{2}}$

(b) Equation for cover/reproduction component. The following equation integrates index values for each variable to obtain a life-requisite value for cover/reproduction.

cover type	equation
EF	Cover/Reprod. Value = $(V_1 \times V_2)^{\frac{1}{2}}$

D. HSI determination. The following steps should be followed:

(1) Determine if all life-requisites are provided at some level greater than zero, considering all cover types under consideration. If any life requisite is not provided the HSI will equal zero and no further calculations are necessary.

(2) Compute the life requisite values for each cover type by collecting field data for each variable and entering these data into the proper suitability index curve and using the index values obtained in the appropriate life-requisite equations.

(3) If substantial variation occurs in the tree canopy closure determine the suitability index for the V_2 variable, percent tree canopy closure, as follows:

1. Stratify the evaluation area into forest types which are wholly or partially within 183 m (600 ft) of a suitable feeding meadow.
2. Determine the area of each forest type and the total area of forest cover being evaluated.
3. Determine the HSI value for each forest type in the evaluation area
4. Multiply the area of each forest type by its respective HSI value.
5. Add all products calculated in step 4 and divide the sum by the total area of all forest types to obtain the weighted HSI value for V_2.

(4) To determine the suitability index for the V_1 variable, snags > 24" dbh per acre, the same procedure outlined in step (3) may be used, or a simple averaged value for V_1 may be obtained based on several transect samples through the evaluation area. Very rarely should this variable give an HSI of 0.0. If this occurs, double-check the adequacy of the sample size.

(5) Based on the limiting factor concept, the overall HSI is equal to the lowest life-requisite value for either food or reproduction.

E. Application of the model. The level of detail needed for a particular application of this model will depend on contraints of time, money and accuracy. Detailed field sampling of all variables will provide the most reliable HSI values. All variables can be estimated to reduce the amount of time required to apply the model. Use of subjective estimates decreases reliability and replicability, and these estimates should be documented.

Definitions of variables and suggested measurement techniques are given in figure 2.

Figure 2. Definitions of variables and suggested measurement techniques.

Variable (Definition)		cover types	suggested technique
V_1	Snags per hectare 61 cm (24 in) dbh or larger (the average no of dead trees per unit).	EF	Belt transects or 1/10 acre plots adequate to sample the probable nesting zone.
V_2	Percent tree canopy closure (the per cent of the ground that is shaded by a vertical projection of all trees over 50 feet tall).	EF	Estimate from aerial photos or measure using line-point transects.
V_3	Hectares of meadow or grassland with herbaceous cover 13 to 38 cm (5 to 15 in) tall. If the site is closely grazed, estimate ungrazed heght for potential.	G	Aerial photos and area-counting instruments. Line-point transects or estimates for vegetation height.
V_4	Percent herbaceous canopy cover (the percent of the ground that is shaded by a vertical projection of all non-woody vegetation).	G	Line-point transect or Daubenmire plot frame.

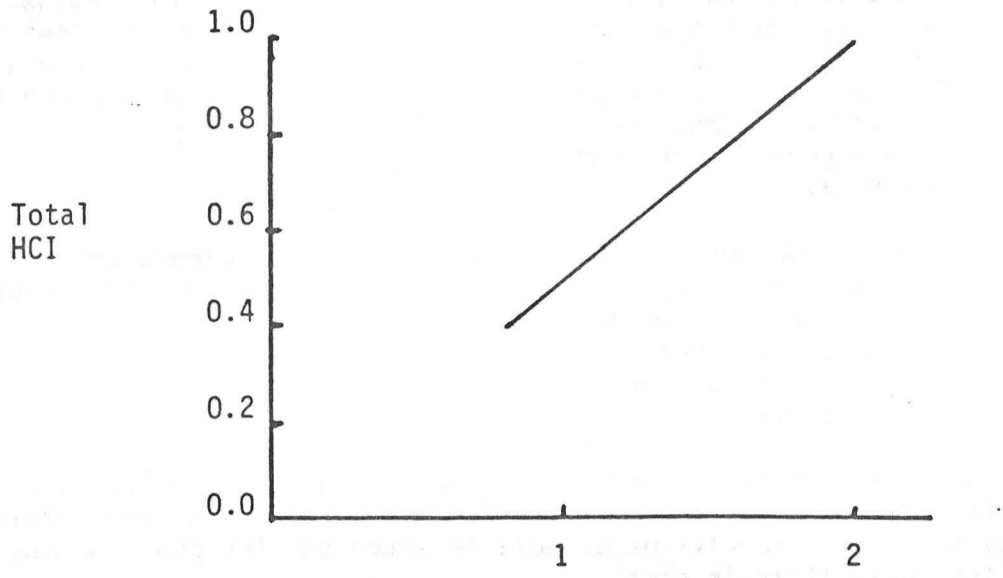
NOTE: As a guide in the field to estimate sample size needed, take sample plots until the ratio of the standard error to the mean of the sample values decreases to 0.1. This will be especially important for sampling snags in stands where the variability is great.

F. Sources of other models. An unpublishedt HSI model (working draft) for meadow vole for (U. S. Fish and Wildlife Service 1980) was used to estimate habitat requirements for montane vole since the two species appear to occupy a similar ecological niche in different geographical areas. The U. S. Fish and Wildlife Service publication "Standards For The Development Of Habitat Suitability Index Models, 103 ESM" (1981) was used as a guide for developing this HSI model.

HABITAT CAPABILITY INDEX MODEL

It is assumed that great gray owl habitats with high HSI values will provide suitable nesting territories on smaller areas than habitats with low HSI values. The following habitat capability index (HCI) shows the estimated relationship between total HSI and the number of breeding pairs which can be supported on 258 ha (640 ac) of suitable habitat. This model is primarily based on three territories which ranged from 155 to 386 ha (383 to 956 ac) in size and from 0.4 to 0.8 in total HSI value. This model has low reliability because of the the small sample it is designed from. It will be refined as more information becomes available.

Capability Index Curve



MANAGEMENT PRESCRIPTIONS

A. Population Objectives

The current population estimate for Yosemite National Park is 20 to 24 birds out of a state-wide population estimate of 60 to 70 birds (Winter 1985). The Sierra Nevada and Northern California mountains have suitable or potentially suitable habitat. Within these habitats the desired population is a minimum of one pair of great gray owls per township.

B. Minimum Management Area

The minimum management area needed to manage for one pair of great gray owls is 258 ha (640 ac). This assumes that in managed forests the total HSI value will generally not exceed 0.5. Potenial habitat will not occur evenly spaced and the objective should be to not exceed 19.4 km (12 mi) between management areas.

C. Habitat Potential

Habitats in California with potential for great gray owl habitat are mixed conifer, red fir, lodgepole pine and wet meadows. Secondary habitats which are occassionaly used in winter are ponderosa pine, valley-foothill hardwood-conifer and grassland.

D. Manageable Habitat Characteristics

Desired habitat is comprised of mature or old growth conifer forests with dense canopy and numerous snags in close proximity to large meadows or meadow systems. If the forest is subject to logging that portion within 183 m (600 ft) of the meadow should be managed to meet these criteria and the meadows should not be excessively grazed by livestock.

C. Management Prescriptions

The 183 m (600 ft) of forest habitat immediately surrounding important prey base meadows should be maintained in an all-aged condition with the largest age class trees at least 61 cm (24 in) DBH, a conopy closure greater than 40% and with numerous snags at least 61 cm DBH and 9.2 m (30 ft) tall. Herbaceous meadow vegetation should be managed for maximum abundance and a hight of 13 to 38 cm (5 to 15 in). Single trees, fence posts or other potential hunting perches within the meadows are desireable.

1. Forest Component
   a. High Capability: Manage for crown canopy 70% or greater and 10 or more snags per ha (4 or more per ac).
   b. Moderate Capability: Manage for crown canopy 40-100% and 5-10 snags per ha (2-4 per ac).
2. Meadow Component
   a. High Capability: Manage for 8 or more ha (20 ac) of meadow with greater than 50% ground cover.
   b. Moderate Capability: Manage for 6 to 8 ha (15 to 20 ac) of meadow with greater than 35% ground cover.

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